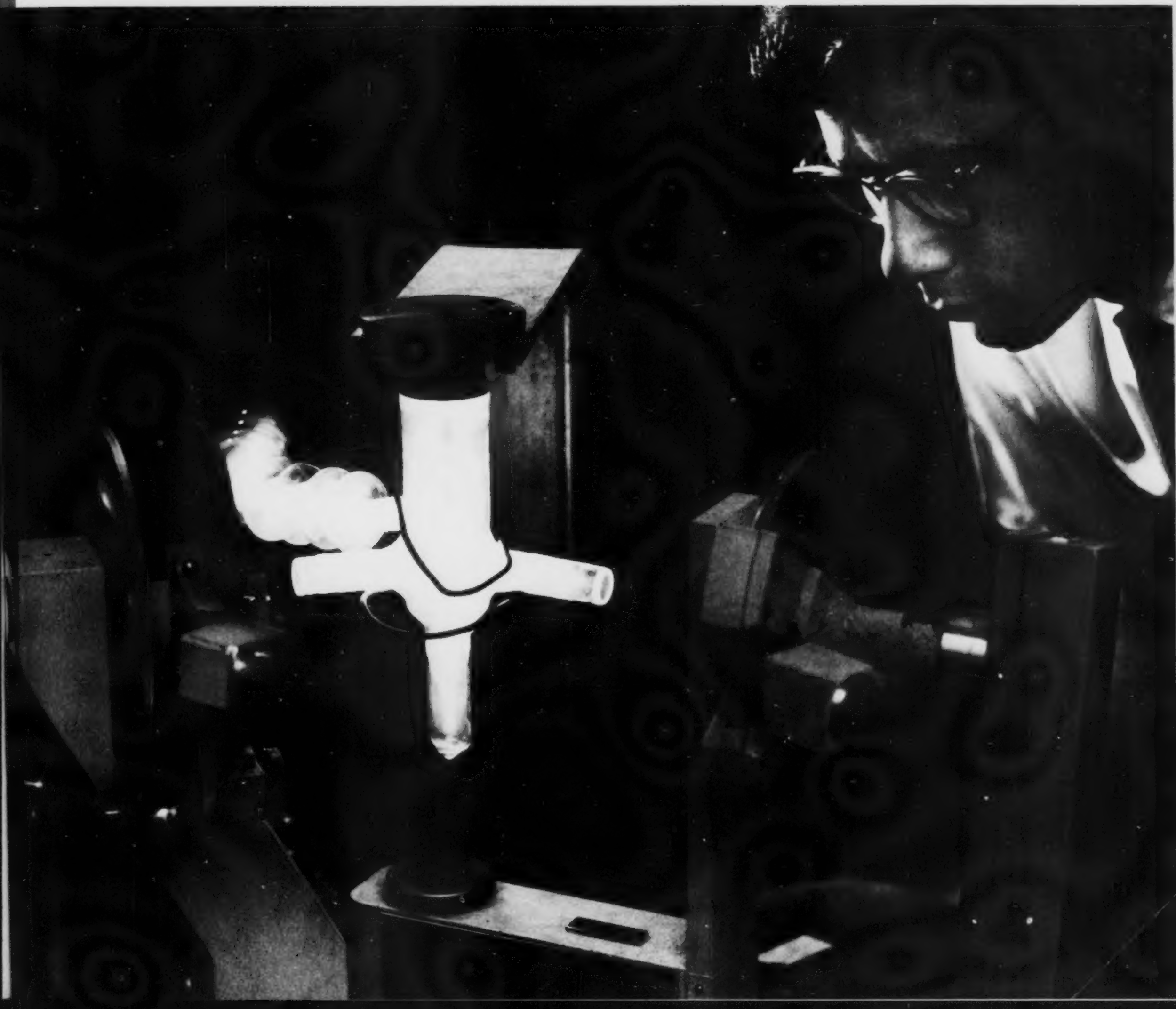
U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News BULLETIN

VOLUME 48 L5.93 56T1 OCTOBER 1964 NUMBER 10 TS



U.S. DEPARTMENT OF COMMERCE LUTHER H. HODGES, *Secretary*

NATIONAL BUREAU OF STANDARDS A. V. ASTIN, *Director*

NATIONAL BUREAU OF STANDARDS
Technical News
BULLETIN

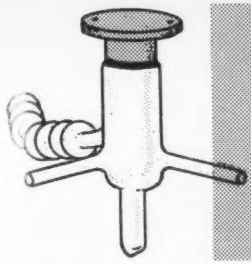
For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: domestic, $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 19, 1961).

Library of Congress Catalog Card Number: 25–26527

October 1964 Issued Monthly Vol. 48, No. 10

Contents

COVER: H. T. Yolken adjusts the flow of hydrogen to an ultra-high-vacuum apparatus as an iron specimen is heated to 800 °C and simultaneously bombarded with hydrogen atoms and ions. This procedure, which produces a glow discharge in the field of an induction coil wrapped around the reaction cell (*center*), is used to clean the specimen surface.



OXIDE FILM INFLUENCES CORROSION

ultra-high-vacuum technique aids study

One of the main factors influencing the oxidation of metal parts is the thin film that exists on a metal surface. Few, if any, experimental data have been published, however, on the initial stages of film formation because it occurs instantaneously in a normal environment. Nevertheless, such data are needed to facilitate basic research on the complex corrosion process. Hence Jerome Kruger and H. T. Yolken of the NBS Institute for Materials Research recently investigated film formation under controlled low-pressure conditions where the reaction is slowed down enough to be studied.

Pressure is a factor. An ultra-high-vacuum system capable of attaining pressures down to less than 10^{-9} torr was employed to prepare film-free surfaces prior to the introduction of oxygen at low pressures, and an ellipsometer was used to measure film growth.[1] Results indicate that the amount of film formed is proportional to time of exposure to oxygen and the rate of growth decreases with decreasing pressures.[2] These findings not only shed light on the early stages of oxidation behavior, they also provide low-pressure film-growth data which should be of value to space technology.

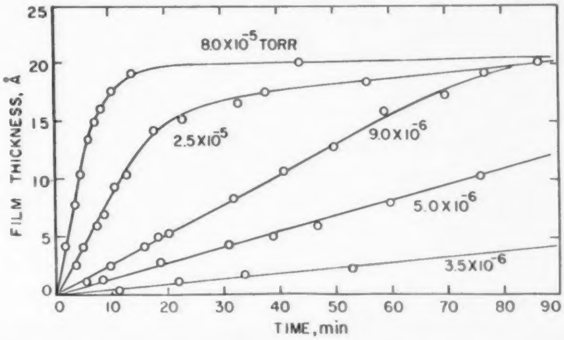
The graph below shows the changes in thickness with time that occur on iron specimens at various oxygen pressures at a temperature of 300 ± 1 °K. All these curves, at times much longer than those shown, approached a limiting thickness of around 26 Å, the same limiting thickness achieved when oxidation is accomplished at normal atmospheric pressure. The curves indicate that, as the oxidation is carried out at increasing oxygen pressures, the time to traverse the linear portion of the curve decreases. This is further proved by additional experiments run at higher pressures—above 10^{-4} torr. The linear portion virtually disappears, and the oxidation process starts to resemble that observed at atmospheric pressure. Thus at around 10^{-4} torr the process becomes pressure-independent.

The results obtained in these experiments agree with Cabrera's theory [3] on the effects of pressure on the oxidation rate of very thin films. According to this theory, the oxygen pressure starts to affect the oxidation rate when the rate of oxygen supply to the surface is not enough to maintain an equilibrium concentration necessary to create the electric field that starts film growth at the metal-oxygen interface. The lower the pressure, the longer it takes for an oxygen molecule to reach the metal surface. Under these circumstances—as the present experiments also show—the rate of the early stages of film growth depends on the value of the oxygen pressure and the rate varies linearly with time.

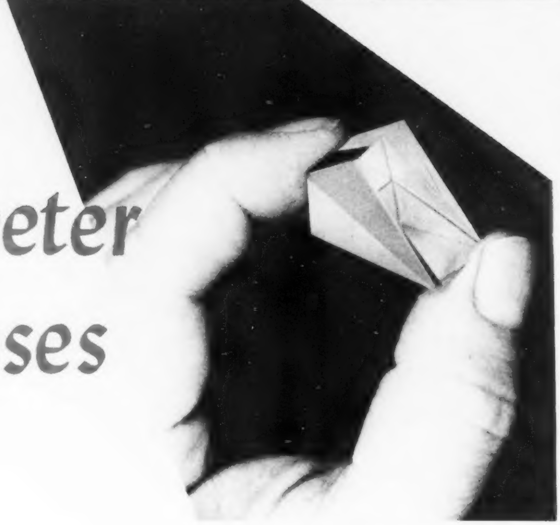
By a least-squares fit of the data obtained in the study to a plot of film growth rate versus oxygen pressure, at pressures below 8×10^{-5} torr, it was found that the sticking probability (i.e., the fraction of the oxygen

(*Continued on page 187*)

Rate of growth of thin oxide films on the surfaces of high-purity iron specimens at low pressures and room temperature.



New Interferometer Tests Large Lenses



Wave-front-shearing interferometer.

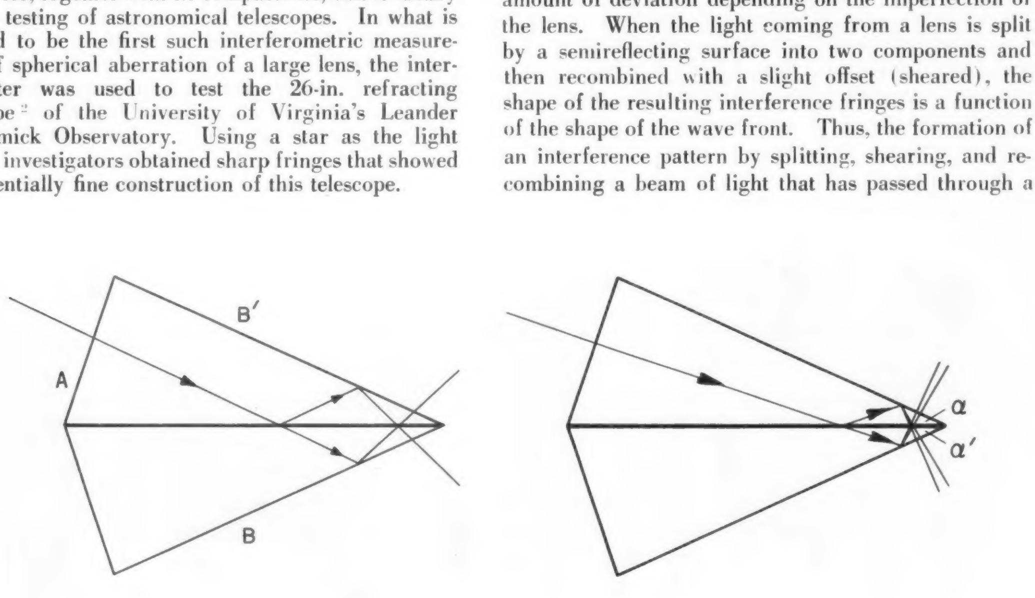
small prism permits determination of spherical aberration

Smaller Size

A wave-front-shearing interferometer[1] that is smaller, simpler, and more rugged than previous designs has been developed by J. B. Saunders of the NBS Institute for Basic Standards. The optical properties of this device, together with its compactness, suit it ideally for the testing of astronomical telescopes. In what is believed to be the first such interferometric measurement of spherical aberration of a large lens, the interferometer was used to test the 26-in. refracting telescope[2] of the University of Virginia's Leander McCormick Observatory. Using a star as the light source, investigators obtained sharp fringes that showed the essentially fine construction of this telescope.

Principle of Operation

The wave front of a beam of light that has passed through a lens will be perfectly spherical if the lens is free from aberrations. If the lens is not perfect, the wave front will deviate from a spherical shape, the amount of deviation depending on the imperfection of the lens. When the light coming from a lens is split by a semireflecting surface into two components and then recombined with a slight offset (sheared), the shape of the resulting interference fringes is a function of the shape of the wave front. Thus, the formation of an interference pattern by splitting, shearing, and recombining a beam of light that has passed through a



Configuration at left provides shear in a plane perpendicular to the plane of the drawing; that at right provides shear in the plane of the drawing.

lens provides a ready means of detecting aberration in the lens.

Practical Application

Despite its apparent utility in optical testing, the wave-front-shearing interferometer has had, prior to this Institute development, very limited practical application. Previous interferometers of this type consist of a bulky arrangement of mirrors, beam dividers, and compensating plates, the size of which severely limits their mobility. Also, the separation of these elements makes them very susceptible to vibration and temperature effects. Other interferometers for testing optics are inconvenient in that precise reference surfaces are needed to provide a standard wave front, and a large beam splitter is required.

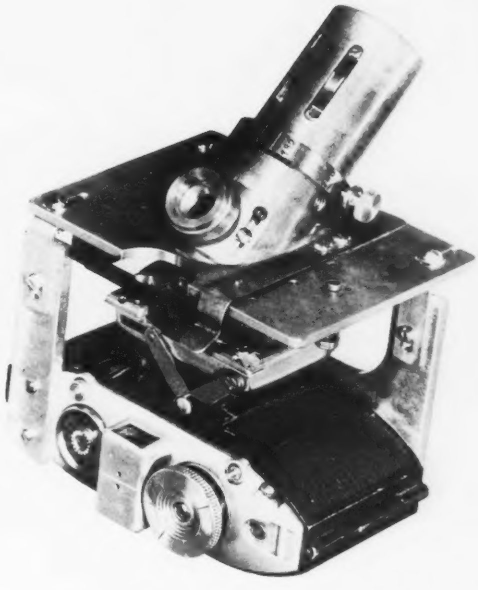
Two Versions

The wave-front-shearing interferometer developed by Saunders is small enough to fit into the hand, and after adjustment at the time of manufacture needs no further attention. One version of the new interferometer consists of two identical triangular prisms cemented together, with a semireflecting surface between the adjoining faces. Before the cement hardens, the prisms are rotated slightly around an axis centered on and normal to the common face. Light entering face *A* (see lefthand diagram) is split by the semireflecting surface into two components, each of which is totally reflected at the outer faces *B* and B^1. The beams recombine at the common face, where they are again divided, two components emerging from each face to form interference patterns. Since the two beams are diverted differently by the prisms (because of the relative rotation of the elements), they emerge at a small angle to one another, thus forming interference patterns. One set of fringes can be used for visual observation, and the other for photographic recording. This arrangement of prisms produces shear in a plane normal to the plane of the drawing.

A second arrangement, which produces shear not by the rotation of the elements but rather by the difference in the angles of the component prisms, is shown in the righthand diagram. This configuration produces shear in the plane of the drawing. If, in addition to the inequality of the angles, the prisms are rotated relative to each other, shear in an oblique orthogonal direction results.

Testing Optical Systems

One of these prism interferometers was mounted in a special holder which can easily replace the eyepiece of an astronomical telescope. In a test of the Leander



The prism interferometer (contained in the tube) and a camera for recording fringes were used in a test of the University of Virginia's 26-in. refracting telescope. The entire assembly shown replaced the eyepiece of the telescope.

McCormick Observatory telescope, in which the star Capella served as the light source, excellent fringes were obtained with a monochromatic filter and a 6-sec photographic exposure. Because of periodic fluctuations in the fringe pattern caused by atmospheric disturbances, visual observations were not made until the fringes were relatively stationary, at which time the exposure was made. Mathematical analysis [3] of the fringes on a series of photographs taken at different angles of shear indicate that the telescope, except for marginal points, performs well within the Rayleigh tolerance of one quarter wavelength. This preliminary use of the interferometer should lead to its wider application in the testing of many types of optical systems.

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[1] The wave-front-shearing prism interferometer, *J. B. Saunders, J. Res. NBS* **68C** *(Eng. & Instr.), No. 3, 135 (July–Sept. 1964).*

[2] Interferometer test of the 26-inch refractor at Leander McCormick Observatory, *J. B. Saunders, to be published.*

[3] Measurement of wave fronts without a reference standard: Part I. The wave-front-shearing interferometer, *J. B. Saunders, J. Res. NBS* **65B** *(Math. & Math. Phys.), No. 4, 239–241 (Oct.–Dec. 1961).*

Improve electrodynamic vibrators with AIR BEARINGS

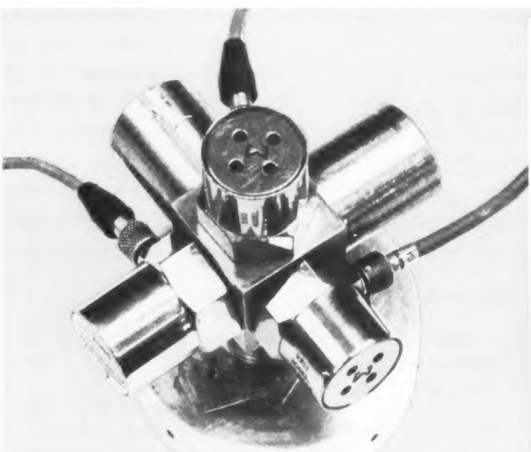
B. F. Payne attaches a velocity pickup to the table of an electrodynamic vibrator. Tubing in foreground supplies air to a bearing which reduces vibrator resonances and transverse shaft motions.

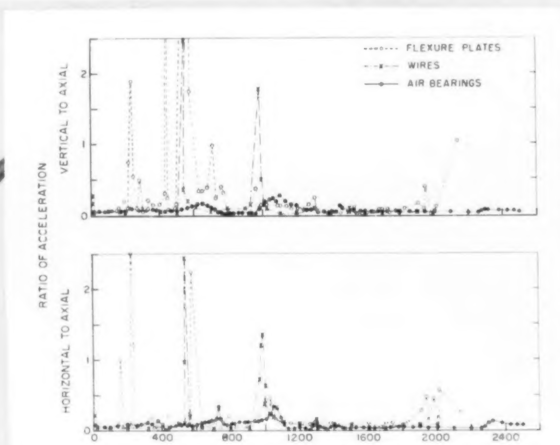
Lateral shaft motion of electrodynamic vibrators can now be minimized with the use of a recently devised air bearing. By reducing unwanted transverse motions and vibrator resonances, it is now possible to obtain increased calibration accuracy and stability in these instruments. T. Dimoff and B. F. Payne at the NBS Institute for Basic Standards have developed and evaluated the air bearings [1] to obtain this increased accuracy, which is required in transducer calibration. This need developed with the increasing use of dynamic mechanical testing and has been accentuated with the arrival of the space age.

Measurements of vibration are made by monitoring the output of acceleration- and velocity-measuring transducers mounted on the device or system being tested. Such a transducer is calibrated by measuring its output, when mounted on vibrators of known characteristics, in response to experimentally varied vibration amplitude and frequency.

An electrodynamic vibrator consists essentially of a massive, doughnut-shaped main magnet having a cylindrical slot in which a driving coil vibrates in response to the alternating current passing through it, much like a huge loudspeaker without a cone. The vibrating coil is attached to a shaft, at one end of which is the mounting table on which is secured the instrument being calibrated. The shaft is free to move axially on a compliant suspension at each end, such as radial wires in tension or flexural plates attached to the vibrator frame. The motion is measured by a velocity-sensing coil mounted on the shaft and moving in a mag-

Left: *Three accelerometers are used in testing performance of an electrodynamic vibrator equipped with experimental air bearings. These and two dummy accelerometers are mounted on the faces of a stainless steel cube, which will be attached to the end of the vibrator shaft.* Right: *Ratios of transverse to axial acceleration for three types of vibrator suspension systems show that air bearings have reduced undesired transverse motions and eliminated some resonances.*





etic field; its output when calibrated permits the xial shaft motion to be known. Unfortunately these uspension methods permit considerable freedom for the ndesired transverse motion and contribute troublesome resonances of their own. For these reasons, the electrodynamic vibrator has been limited as a vibration standard.

The NBS scientists employed air bearing suspensions as a way of permitting unrestrained axial motion while minimizing transverse motions. They installed experimental air bearings in place of the original flexure plates of a vibrator, surrounding the aluminum moving surfaces with bearing shells of brass with a 0.001-in. radial clearance. A pressurized air distribution channel surrounds each brass bearing surface and opens to it through several orifices.

The modified electrodynamic vibrator was operated with filtered air, regulated at a pressure of 50 psig, supplied to the annular distribution rings through hoses. The air bearing-equipped vibrator was found to be far superior in respect to transverse motions. The pressure of the air used was apparently not a critical factor in performance, as no significant changes were observed for variation between 20 and 80 psig and as little as 5 psig was found to support the moving components without bearing contact, in no-load tests.

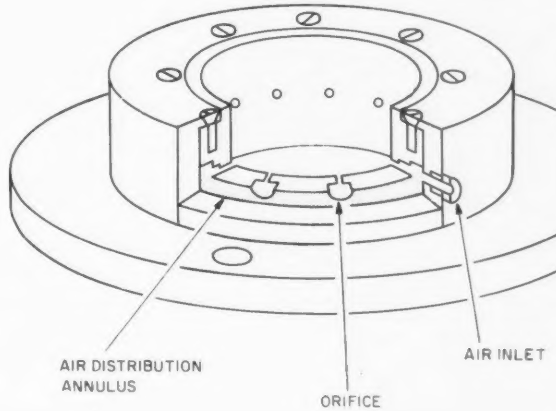
Transverse motions of the modified vibrator were measured by three piezoelectric accelerometers attached to a steel cube mounted on the vibrator table. The sensitive axis of one was parallel to the vibration axis and those of the other two at right angles to it, one measuring horizontal and the other vertical transverse acceleration. Two dummy accelerometers to balance the load were attached to the two unoccupied faces of the cube. The horizontal and vertical accelerations were each plotted as ratios to the corresponding axial acceleration at frequencies in the range of interest as indexes of suspension characteristics, a low ratio indicating good performance.

The NBS scientists compared the transverse-to-axial ratios of the air-bearing-equipped vibrator and vibrators using flexure plates and wire suspensions at frequencies from 0 to 2500 Hz (c/s). Ratios obtained for conventional suspensions exceeded 2 (twice as great a transverse as axial motion) for some resonances, while for air-bearing-equipped vibrators the ratio never exceeded 0.3.

Calibration of Vibrators

The vibrator equipped with air bearings was calibrated by means of the reciprocity, fringe disappearance, and optical target methods. The reciprocity method assumes that the reciprocity theorem applies—that displacement, velocity, and output voltage increase linearly with driving force and voltage. The reciprocity calibration was made by first determining the nominal transfer function between the driving and velocity-sensing coils, and then the voltage ratio of the sensing and driving coils when driven by another shaker at frequencies varied over the range of interest. A high ratio occurs where the voltage developed in the sensing coil would increase for a constant driving voltage, a characteristic of resonance.

The calibrations made by means of the reciprocity method were compared with interferometric calibrations and those made by use of an optical target. Plots of calibration factors, or sensitivity, show excellent agreement among the calibration methods. The reciprocity calibration yielded a sensitivity of 0.1857 V/in./sec from 10 to 400 Hz, compared with the same figure for the interferometric method for frequencies from 350 to 750 Hz and with 0.1859 V/in./sec for the optical target method for seven frequencies.



Air bearing for electrodynamic vibrators consists of a bushing surrounded by an air distribution annulus. Air is supplied to the annulus at 50 lb/psig and to the bearing surface by several inlets from the annulus.

[1] Application of air bearings to an electrodynamic vibration standard, *T. Dimoff and B. F. Payne, J. Res. NBS* **67C** *(Eng. & Instr.), No. 4, 327–333 (Oct.–Dec. 1963).*

VIGILOMETER

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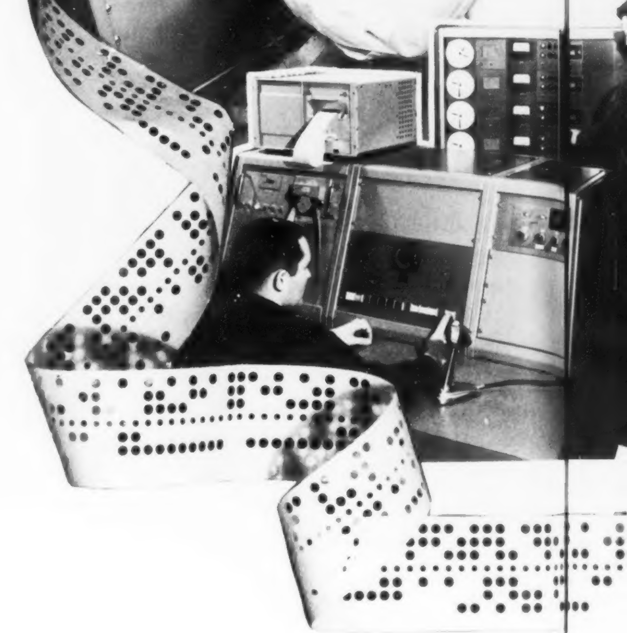

Engineers of the NBS Institute for Applied Technology have designed a computer-type research apparatus to determine how the monitoring performance of Army personnel is affected by such factors as time on duty, distractions, and the characteristics of displays being monitored. The machine, known as a Vigilometer, was developed at the Institute for the U.S. Army Personnel Research Office (USAPRO) to simulate a wide range of visual and auditory monitoring tasks, and to measure the effectiveness of monitoring personnel under a variety of conditions.

The Army's applications for the Vigilometer will be mirrored in industry, wherever it is desired to record reactions of a large number of subjects to a sequence of stimuli. The psychologist can use it to study thresholds of attention for different modes of presentation and distraction (How much noise will it take to neutralize a flashing green light half the time?) and variations due to body state (hunger, fatigue, and chemicals), as well as conditions governing learning. The human engineer can use it to create more effective automobile instrument panels, error-free work environments, and even more effective advertising devices.

The key design engineers responsible for achieving the Vigilometer's operational requirements were Ernest Ainsworth and Philip Shupe of the NBS Information Technology Laboratory, working under the direction of James P. Nigro. The functional requirements and major performance specifications of the Vigilometer were developed by John G. Tiedemann, Monitor Performance Task Leader, USAPRO, to meet U.S. Army research requirements. Also instrumental were Delaney A. Dobbins, former Task Leader, and Philip J. Bersh, Chief of USAPRO's Combat Systems Research Laboratory. Findings obtained with the Vigilometer will help U.S. Army research scientists improve work methods and identify vigilant personnel for monitoring jobs.

The importance of vigilance in performing crucial duties has been recognized by armies at all times the world over, as attested to by the traditional death penalty for the sleeping sentry. Vigilance remains a problem, although today's sentry often stands watch over a radarscope or is aided by an electronic alarm system. The difficulty of remaining alert has been increased by the remote character of the warning and the relatively passive participation of the observer.

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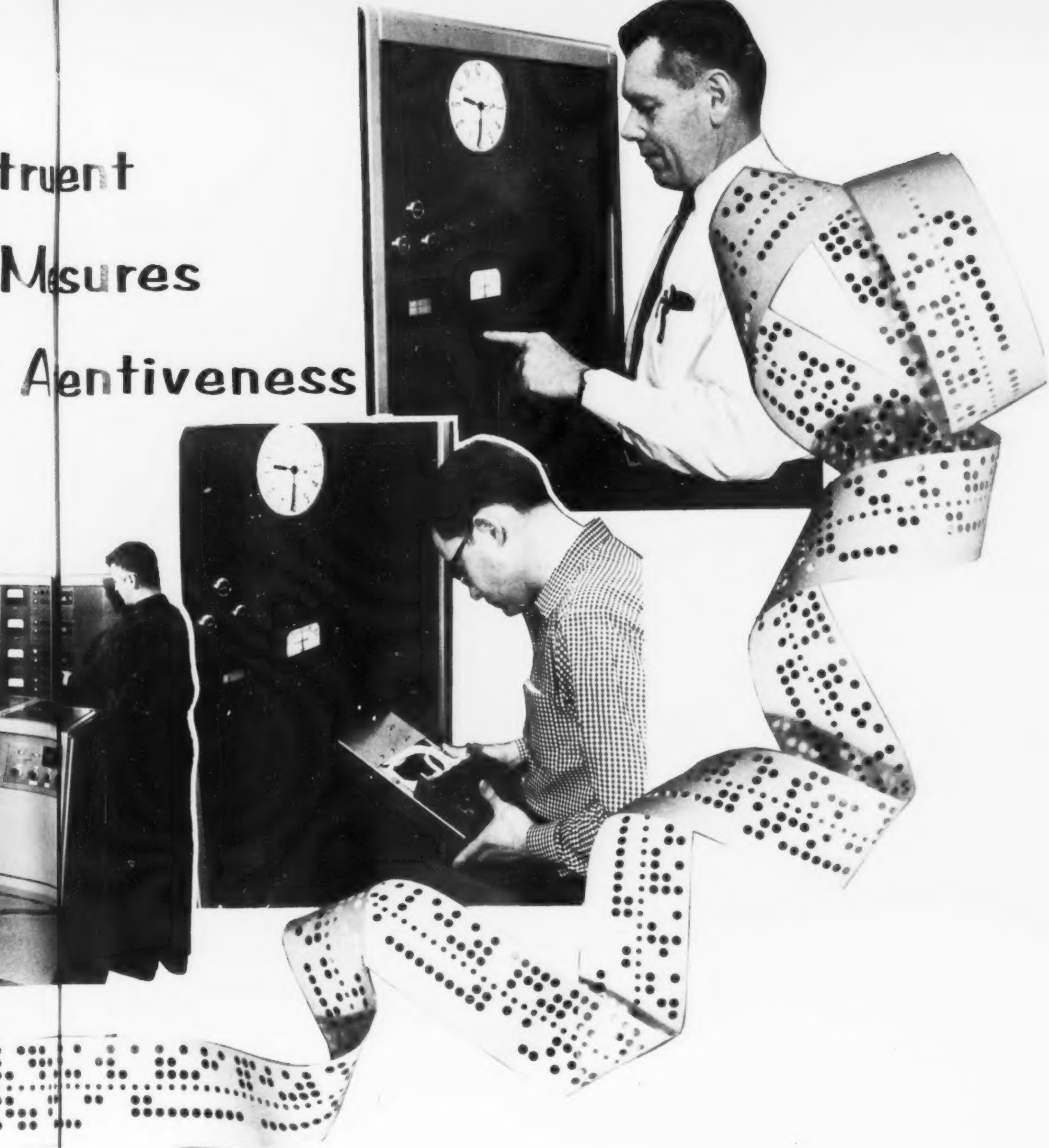


Left to right: (1) *James Nigro demonstrates how the psychological researcher selects the stimulus characteristics at the encoding unit and records the instructions on the tape.* (2) *Ernest Ainsworth threads a punched tape on the reading head of the Vigilometer to program and administer a test.* (3) *Army specialist Michael DeGennaro, seated at the control console, tests responses made by NBS technician James McNally.* (4) *Ural Jones inserts an alphanumeric display module.* (5) *Philip Shupe responds to a critical meter indication at a monitor console.*

The USAPRO Vigilance Laboratory will study the alertness and reliability of men standing watches on monitoring instruments. The Vigilometer controls stimulus situations and records the responses of up to five subjects at a time. Analysis of the responses will help Army behavioral scientists to relate monitor performance to such factors as environmental constraints, supervisory controls, fatigue, distraction, and the type and pattern of display. The findings will be useful in the field of personnel utilization, particularly in specifying optimum work methods and conditions.

Vigilometer Console

The Vigilometer is actually two machines in one, the first programming the timing and magnitude of both critical and distracting stimuli and the second recording the responses of the subjects. Its essential circuitry, contained within a console the size of a large desk, controls the display instruments at the test stations and records the results. The experimenter merely inserts a paper tape, which he has previously punched or selected for the desired stimulus program, into the tape reader and starts the machine in its programmed sequence of stimuli. A "library" of taped programs can be built up for the various programs used and new ones can be punched when needed.

Test Stations

Each of the five subject test stations at the Vigilance Laboratory is in a soundproof "isolation booth" connected to the console by five cables carrying 25 subchannels, each a stimulus-response set. The subjects being tested are told what constitutes a critical stimulus—perhaps a red light, an audible 1000-Hz buzzing, or a galvanometer deflection greater than three divisions from center, for example—to which each subject is to respond by pushing a button on the stimulus module of his station. The subjects are then seated in individual booths and exposed to the series of stimuli, some critical and others noncritical, until the *halt* command on the tape ends the experiment.

Each test station consists of a number of paired indicators and response buttons, one kind of indicator to each module mounted in the station equipment rack. The instrument modules supplied with the Vigilometer are of five types, having as their respective instruments or indicators (1) a nullmeter, (2) an oscilloscope, (3) three pairs of red and green warning lights, (4) a five-digit alphanumerical display, and (5) an auditory presentation by loudspeaker or headset. A sixth type of module has a clock on its panel but is not used in evoking responses. The types can be selected and located in the rack's 24 pigeonholes to best suit the needs of the experimenter. Each module contains on its 6-in.-sq front panel its instrument or indicators and the associated pushbutton(s) for responding to critical stimuli. The module is electrically connected, when it is pushed all the way in, by a connector at its rear mating with a console module connector; the module can then be locked in place.

Recording Data

The Vigilometer includes a printout device to record the individual responses and totals of response types. This device is operated by the computer portion of the machine, which categorizes each response according to whether it was associated with a critical signal, noncritical signal, or no signal, and tallies each response received by type, subject (station), and channel (each accommodating up to five instruments). The machine also tallies each stimulus on registers for critical and noncritical stimuli on each channel, raising to 85 the number of registers maintained in the machines.

The printer prints intermittently—one line for each signal or response—on a paper tape from the time the Vigilometer is placed in operation until it reaches the *halt* instruction. It prints each line of nine characters simultaneously in 0.2 sec, identifying the station (one of five), the channel (one of five), the type of response (one of three), and the time in centi-seconds since the last response on that channel.

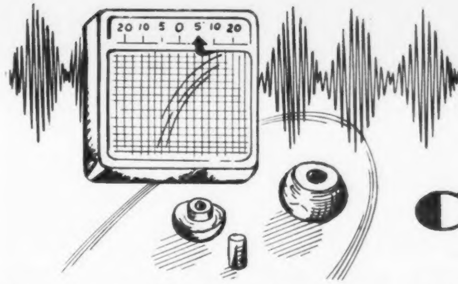
Each response received is first read into the "printer backlog" section of the machine's memory. The printer scans the memory after each operation, and repeatedly while not printing, to pick up new data to be printed.

The printer not only produces a description of each response, but on receiving a *summary printout* instruction from the taped program prints a summary of the 85 categories of data stored, including both response and stimulus data on each of the five channels. This instruction not only can be given just before the *halt* instruction, but also can be encoded at any desired intermediate points on the program tape or can be manually called for at any time by the experimenter. On receiving this order during the stimulus program, the printer produces a printout of all 85 lines of cumulative data in 15 seconds and then goes on to print any further data that have been stored in the printer backlog memory during this operation.

Variations in Instruments

The many modules and their possible locations at each station permit evaluation of the effects of instrument location, sensitivity to competing stimuli, and the distraction potential of various modes. Experimentation with such variations makes it possible to recommend the best presentation of stimulus material for various Army monitor jobs.

Studies can also make use of programmable variations in stimulus detail. Not only can the clock be run at accelerated rates, but one of nine warning-light intensities can be used, one of 19 possible deflections of the nullmeter, five audio frequencies for auditory presentation, and eight amplitudes. The pulses displayed on the oscilloscopes can be varied in position, width, and amplitude so that the pattern presented is under machine control. Experimentation will permit U.S. Army Personnel Research Office psychological investigators to determine thresholds and equated amplitudes for the stimulus types studied. More types of modules can easily be added as required for studies using the Vigilometer.



STANDARDS AND CALIBRATION

Humidity Calibration Service Now Available

The NBS Institute for Basic Standards has initiated a service for the calibration of humidity-measuring instruments.[1] This service is being offered to both Government agencies and the public; however, only instruments suitable for use as laboratory or plant standards and having high accuracy and stability are being accepted for calibration.

The calibrations will normally be performed by subjecting the instrument under test to atmospheres of known moisture content produced by the NBS two-pressure humidity generator.[2] The generator, in turn, is calibrated against the NBS standard gravimetric hygrometer recently developed in the Institute's humidity measurements laboratory.[3]

Calibration results are reported in terms of dewpoint temperature (°C), mixing ratio (grams of water vapor/kilogram of dry air), volume ratio (parts of water vapor/million parts of air), or relative humidity (percent). The ranges over which calibrations can be performed and the accuracies (as indicated by the uncertainties) with which the humidities in these ranges can be achieved are shown.

When higher accuracies are required, the instrument under test will be calibrated against the NBS standard gravimetric hygrometer. Such higher accuracy is available on a limited basis over a mixing ratio range of 0.30 to 20 g/kg with 0.1% uncertainty. In this range, the moisture content of air is determined with an estimated maximum uncertainty (systematic error plus 3 standard deviation) of 13 parts in 10^4.

Ranges and uncertainties attained in producing air of known moisture content by means of two-pressure humidity generator

Unit	Range	Uncertainty
Dewpoint temperature—°C	−70	±1.2
	−65 to −55	0.6
	−55 to −40	.5
	−40 to −20	.2
	−20 to +25	.1
Mixing ratio—*g/kg*	0.0013 to 0.0125	±0.0003
	.0125 to .1530	.0015
	.1530 to 20.0	0.5% of value
Volume ratio—*ppm*	2 to 20	±0.5
	20 to 80	1.4
	80 to 250	4.0
	250 to 30,000	0.5% of value
Relative humidity—percent at ambient temperatures:		
of −55 to −45 °C	10 to 98	±2.5
−45 to −20 °C	10 to 98	2.0
−20 to +40 °C	10 to 98	0.5

[1] *Information regarding the fees charged for these calibrations may be obtained from Test Administration, Accounting Division, National Bureau of Standards, Washington, D.C., 20234. This information will also be published in an amendment to NBS Misc. Publ. 250,* Calibration and Test Services.

[2] Pressure-humidity apparatus, *by Arnold Wexler and E. D. Daniels, J. Res. NBS* **48,** *269 (1952).*

[3] A comparison between the NBS two-pressure humidity generator and the NBS standard hygrometer, *by S. Hasegawa, R. W. Hyland, and S. Rhodes; also,* The NBS standard hygrometer, *by Arnold Wexler and R. W. Hyland, both in* Humidity and Moisture *(Proc. 1963 Intern. Symp. Humidity and Moisture) (Reinhold Publ. Corp., New York, N.Y., in press); also,* Gravimetric hygrometer for precise measurement of humidity, *NBS Tech. News Bull.* **47,** *122 (1963). Also see NBS Mono. 73,* The NBS standard hygrometer, *available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 30 cents.*

Germanium Resistance Thermometers

The NBS Institute for Basic Standards is now accepting germanium resistance thermometers for calibration over the range 2 to 5 °K. Germanium resistors submitted for this service will be compared with NBS germanium resistance thermometers of high sensitivity that have been calibrated with reference to the 1958 He^4 scale of temperatures.[1]

Germanium resistance thermometry is widely used throughout fundamental and applied research in the liquid-hydrogen and liquid-helium temperature ranges. Applications include the study of fuels for rockets and missiles, solid-state devices for space-borne computers, and the phenomenon of superconductivity. The new calibration service should be most helpful to research and standards laboratories and to the aerospace and other industries.

For further information, write to Dr. H. H. Plumb, Cryogenic Physics Section, National Bureau of Standards, Washington, D. C. 20234.

[1] The 1958 He^4 Scale of Temperatures, *introduction by F. G. Brickwedde; tables by H. van Dijk, M. Durieux, J. R. Clement, and J. K. Logan, NBS Mono. 10 (1960). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 20c.*

Topside Sounder in Orbit

The Ionosphere Explorer A satellite was launched at 6:43 a.m. (MST) August 25, 1964, from the Pacific Missile Range at Point Arguello, Calif. It will provide valuable new data on the ionosphere for the NBS Central Radio Propagation Laboratory in Boulder, Colo.

Under sponsorship of the National Aeronautics and Space Administration, the satellite is instrumented for experiments proposed by the Ionosphere Research and Propagation Division, headed by Robert W. Knecht. This Division has the responsibility for the processing, scientific evaluation, and dissemination of data received from 13 telemetry stations around the world. The station at College, Alaska, began receiving signals from the satellite at 8:20 a.m.

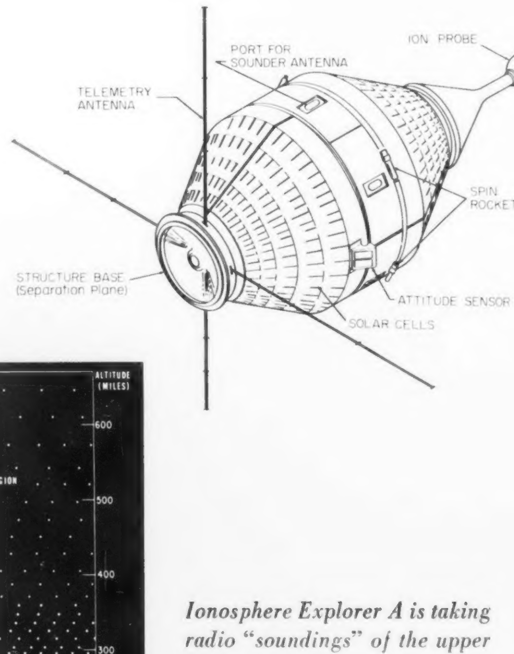
Placed into a polar orbit by a four-stage solid-propellant Scout rocket, the 100-lb package will observe the ionosphere, in the range of latitudes 80°N to 80°S, many times in the 6-mo to 1-yr life of the experiment.

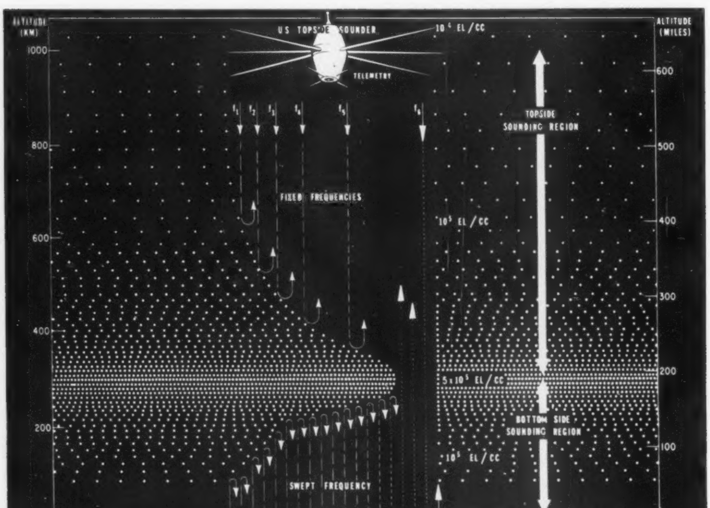
The purpose of the Ionosphere Explorer A satellite is to obtain data on the electron density distribution of the ionosphere from its top side—the tenuous and relatively unknown region of the atmosphere above 200 mi altitude. These data will represent an important advance in research on worldwide radio communications and will contribute to man's understanding of the high atmosphere.

Overall management of the NASA topside sounder program is the responsibility of the Goddard Space Flight Center, Greenbelt, Md. The satellite itself was designed and constructed by the Airborne Instruments Laboratory of Cutler-Hammer, Inc., Long Island, N.Y. An attached ion probe is the work of the University College of the University of London, England.

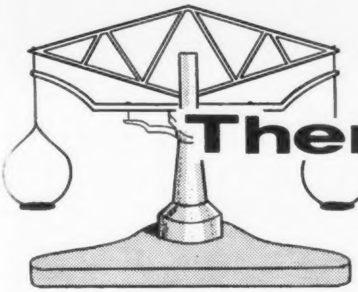
The topside sounder program at the Bureau in Boulder is under the direction of Mr. Knecht and Wynne Calvert. The engineering phases of the NBS program are directed by Earl E. Ferguson with James T. Watts acting as a consultant.

A new telemetry station with a large antenna array, FM receivers, and a tape recorder was constructed near Boulder at Gun Barrel Hill. With this station and others spread around the world, data relayed by a very-high-frequency telemetry link from the satellite will be recorded on magnetic tapes for later analysis. The antenna array at the Gun Barrel Hill station consists of eight cross-polarized yagi antennas to receive signals from the satellite and one helix antenna to transmit radio commands to the satellite, mounted on a steerable frame atop a single column. With this station, the Bureau can record data while the satellite is within 2000 mi of Boulder.





Ionosphere Explorer A is taking radio "soundings" of the upper ionosphere at six fixed frequencies, using the same pulsed radar signal used by ground stations in obtaining data on the lower ionosphere.



Thermal Gradients— effects on balances

Source of Instability

A variety of environmental factors can affect the stability of indication of highly precise balances. Vibration, for example, has long been recognized as a disturbing influence, and care is taken in most laboratories to minimize its effects.

The consequences of another, often unrecognized, source of instability—thermal gradients within the balance case [1]—have been investigated by L. B. Macurdy of the Bureau. He found that the most consistent performance of two-pan balances is achieved when no horizontal gradients are present, and when air at the top of the case is warmer than at the bottom. Instabilities increase when an isothermal condition exists, and become still worse when air at the bottom is warmer than at the top. A vertical gradient (top warmer) of at least 0.3 °C/meter appears necessary for stability to be achieved. Such a gradient can be established through proper control of the environment, and through use of an insulation scheme that permits heat to enter the lower front of the case and traps warm air at the top.

Many balance users have noticed, and some have reported,[2] that the rest point of a precision two-pan balance may change for no apparent reason. Often, redeterminations of the rest point over an extended time period reveal a periodic effect, with periods from seconds to 30 min or more. Changes of rest point large enough (0.6 mg) to prevent precision weighing have been observed. These periodic effects are largely reduced when horizontal temperature gradients are eliminated and a slight vertical gradient, with the top warmer, exists. Unless such thermal conditions hold, initial stability of the air within the closed balance case cannot be achieved. Once stability is reached, the effects of external thermal gradients, and of internal air currents caused by the motion of beam and pans, are localized and damped out by the vertical gradient. Otherwise, air set in motion within the case may continue in motion for some time.

Microchemical Balance

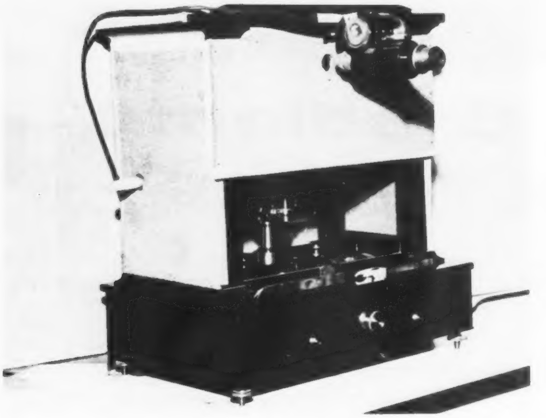
The initial Bureau studies of the effects of thermal gradients were made with a microchemical balance having a glass case and a wooden frame. Light bulbs were placed around the exterior of the case to provide limited and controlled heating, and thermocouples were positioned within the case to indicate both horizontal and vertical thermal gradients. Once the desired thermal conditions were established, four consecutive determinations of the rest point were made, each determination being followed by a reading of the various thermocouples to confirm thermal stability. These preliminary studies clearly revealed that under the experimental conditions the balance responded systematically to changes in the horizontal end-to-end gradient, and that the magnitude of the response depended on the vertical gradient. An end-to-end change of 0.6 °C when the top was 0.1 °C warmer than the bottom gave a 38-μg range in balance indication; the same change in horizontal gradient produced a 68-μg range when no vertical gradient existed, and a 139-μg range when the bottom was about 0.2 °C warmer than the top. These results established that relatively minor temperature gradients can result in large changes in balance indication. When tests were repeated with different total pan areas, a clear dependence of the response on the area indicated that air currents and not thermal effects on the beam were the cause of the instability.

Automatic Recording

Another test that confirmed these findings was conducted with a balance having provision for automatic recording of its indication. This balance, with the beam unarrested, was taken from a state in which the top was warmer to one in which the bottom was warmer and then back to the top warmer condition again. Continuous recording of the balance indication showed that as the vertical gradient approached zero, instabilities commenced which increased as the bottom became warmer than the top. As the top was allowed to warm, these instabilities decreased, and stability was reached when the top was once again warmer than the base. Again, a condition in which the bottom was but slightly (0.4 °C) warmer than the top resulted in rest point changes sufficient to prevent precision weighing.

Damping Effects

A test was then devised to show the damping effects of various types and configurations of insulation on the disturbance caused by a "standard heat pulse." Again



Precision two-pan balance and case, showing arrangement of cork insulation.

a balance with a servorecording system was used, and heat was supplied by light bulbs positioned 6 in. from one end of the balance. A standard pulse consisted of the heat produced by operating the lamps for 5 min. Of the many insulation schemes tried, that with approximately ½ in. cork on the top and down both sides, but only halfway down the front and back, proved most successful. Such a configuration is used in the NBS Mass Laboratory because of its marked attenuation of thermal disturbances. This arrangement of insulation not only provides ready viewing of the pans and pointer, but also permits heat to flow in from the observer and to warm some of the air, which rises to the top and helps maintain the desired thermal condition. Total insulation of the case has the undesirable effect of bringing the balance to an isothermal condition, which is less stable than that with the air at the top being warmer.

Obviously, such major heat sources as the bulbs placed in some balances to illuminate the scale should, if possible, be removed, or a lower wattage bulb substituted. Also, it may be necessary to shield the balance from unequal radiation coming from the walls. An air-conditioning system that releases large quantities of cold air can create undesired thermal gradients within the case. The best environment is probably one whose temperature is rising slowly, with the temperature of the balance lagging slightly behind.

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[1] Response of highly precise balances to thermal gradients, *L. B. Macurdy, J. Res. NBS* **68C** *(Eng. & Instr.), No. 3, 135 (July–Sept. 1964).*

[2] Etudes sur la balance, *Travaux et Memoires du Bureau International des Poids et Mesures 5, 1886.*

Postdoctorals Appointed

The maximum number (20) of NBS Postdoctoral Associateships has been awarded for the coming year to young physicists, chemists, and mathematicians. The Postdoctoral Resident Research Associate Program, supported financially by the Bureau and administered by the National Academy of Sciences—National Research Council, gives promising young Ph. D.'s an opportunity to receive further training through advanced research under the guidance of senior NBS scientists.

In 1955 the Bureau, in cooperation with the National Research Council, initiated the first postdoctoral research program in a Government laboratory. Previous to that time postdoctoral study in the United States was traditionally done at a college or university. Such a program not only assists in the training and development of the country's best young scientists; it also encourages an interchange of ideas, bringing the benefits of the scientist's fresh approaches and the results of his research to the organization sponsoring the work. In addition, although recruitment is not the objective of this program, over one-third of the Associates have joined the permanent NBS staff at the end of their appointment.

Early in the fall each year the National Academy of Sciences announces the program to all universities which grant Ph. D. degrees in the physical sciences. The competition on which the awards are based is open to United States citizens who expect to have completed all the requirements for their doctorate degrees by the time they are ready to begin their appointments. Candidates may apply directly to the Academy before February 1, and the awards are normally announced in April. The appointments are for one year with the possibility of extension for a second year.

Postdoctoral Research Associates appointed for 1964–65 are

William R. Brennen, from Cambridge, Mass., Ph. D. in chemistry from Harvard University, who will study rotational relaxation in excited CH molecules and vibrational distributions in the nitrogen afterflow under Dr. T. Carrington.

Richard A. Brualdi, from Syracuse, N.Y., Ph. D. in mathematics from Syracuse University, who will study the Kronecker product and other combinatorial topics under Dr. M. Newman.

Daniel B. Butrymowicz, from Cincinnati, Ohio, Ph. D. in metallurgy from the University of Cincinnati, who will study chemical interdiffusion in binary alloys and its relation to tracer diffusion results under Dr. J. R. Manning.

George V. Calder, from Berkeley, Calif., Ph. D. in chemistry from the University of California, Berkeley, who will study infrared spectra and photolysis of some halogen oxides of the type X_2O and XO_2 in inert and reactive matrices under Dr. D. E. Mann.

James C. Carter, from New Orleans, La., Ph. D. in physics from Catholic University, who will study classification of nuclear states according to SU_3 symmetries in the *s–d* and *p–f* shells under Dr. S. Meshkov.

Alan F. Clark, from Ann Arbor, Mich., Ph. D. in physics from the University of Michigan, who will study thermoelectric power of electron-impurity scattering at very low temperatures under Dr. V. D. Arp (Boulder).

John M. Daniels, from Waltham, Mass., Ph. D. in chemistry from Brandeis University, who will study the electron paramagnetic resonance of free nitrogen halide radicals under Dr. H. E. Radford.

George T. Davis, from Charlottesville, Va., Ph. D. in chemistry from Princeton University, who will study dynamic mechanical properties of semicrystalline polymers under Dr. R. K. Eby.

David L. Ederer, from Ithaca, N.Y., Ph. D. in physics from Cornell University, who will study the photoionization cross section of xenon in krypton in the 100 to 400 Å region under Dr. R. P. Madden.

Paul D. Goldan, from Champaign, Ill., Ph. D. in physics from the University of Illinois, who will study collision processes in atmospheric gases and undertake determination of electron and ion recombination rates under Dr. E. E. Ferguson (Boulder).

Robert L. Kuczkowski, from Somerville, Mass., Ph. D. in chemistry from Harvard University, who will study microwaves of some of the lower halides of sulfur under Dr. D. R. Lide, Jr.

Sidney B. Lang, from Rehovoth, Israel, Ph. D. in engineering from the University of California, Berkeley, who will study pyroelectric thermometry at low temperatures under Dr. T. M. Flynn (Boulder).

Howard P. Layer, from Chapel Hill, N.C., Ph. D. in physics from the University of North Carolina, who will study the origin of dislocations in metal crystals grown from the melt under Dr. R. L. Parker.

Joseph H. Macek, from Troy, N.Y., Ph. D. in physics from Rensselaer Polytechnic Institute, who will study prethreshold resonances in electron-atom collisions under Dr. U. Fano.

Alan D. Mighell, Princeton, N.J., Ph. D. in chemistry from Princeton University, who will study methods to solve phase problems under Dr. S. Block.

James P. Neal, III, from Champaign, Ill., Ph. D. in engineering from the University of Illinois, who will study electromagnetic wave propagation in anisotropic and isotropic media under Dr. H. V. Cottony (Boulder).

Ralph J. Nossal, from Bruxelles, Belgium, Ph. D. in chemistry from the University of Michigan, who will study statistical mechanics and irreversible thermodynamics under Dr. R. W. Zwanzig.

Alfred Scala, from Brooklyn, N.Y., Ph. D. in chemistry from the Polytechnic Institute of Brooklyn, who will study the photodecomposition of cyclopentadienones under Dr. P. Ausloos.

Harvey P. Utech, from Cambridge, Mass., Ph. D. in metallurgy from the Massachusetts Institute of Technology, who will study the effect of convection on the solidification structure of aluminum single crystals under Dr. L. M. Kushner.

George C. Yang, from Syracuse, N.Y., Ph. D. in physics from Syracuse University, who will study spin lattice and spin-spin relaxation in solids under Dr. T. Chang.

Oxide Film Influences Corrosion

(Continued from page 175)

molecules that may be expected to stick on the metal surface) is about 5×10^{-3}. This low sticking probability increases the time required to reach an equilibrium concentration of oxygen ions on the metal surface. The experimental results indicated that at the various low pressures studied the sticking probability does not vary with changes in pressure.

Water is a factor. In some of the experiments, quite striking results were obtained when small traces of water were introduced into the vacuum system. The first effect was a sudden leveling off in the increasing thickness versus time curve. Secondly, the limiting film thickness achieved was 8 Å less than that observed at the various low pressures in the absence of water. It therefore appears that the presence of water changes the energy barrier over which metal ions must move during that part of the film-growth process in which an equilibrium concentration of oxygen ions is maintained.

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[1] *For further detail, see* Optical measurements on thin films of condensed gases at low temperatures, *J. Kruger and W. J. Ambs, J. Opt. Soc. Am.* **49**, *1195 (1959), and* Optical properties of condensed gases, *NBS Tech. News Bull.* **44**, *171 (1960).*

[2] *For further detail, see* Room temperature oxidation of iron at low pressures, *J. Kruger and H. T. Yolken, Corrosion* **20**, *29t (1964).*

[3] On the oxidation of metals at low temperatures and the influence of light, *N. Cabrera, Phil. Mag.* **40**, *157 (1949).*

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Vol. 48, No. 9, September 1964. 15 cents. Annual subscription: $1.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

CRPL Ionospheric Predictions for December 1964. Three months in advance. Number 21, issued September 1964. 25 cents. Annual subscription: $2.50; 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards.

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75; single copy, 70 cents.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75; single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75; single copy, 75 cents.

Section D. Radio Science. Issued monthly. Annual subscription: Domestic, $9; foreign, $11.50; single copy, $1.00.

Current Issues of the Journal of Research

J. Res. NBS 68A (Phys. and Chem.), No. 5 (Sept.–Oct. 1964).

Relaxation modes of trapped crystal point defects: the three-neighbor shells model in NaCl. A. D. Franklin, A. Shorb, and J. B. Wachtman, Jr.

Viscosity of a standard soda-lime-silica glass. A. Napolitano and E. G. Hawkins.

Hydrothermal preparation of a gehlenite hydrate. E. T. Carlson.

Action of water on calcium aluminoferrites. E. T. Carlson.

Infrared spectra of the crystalline inorganic borates. C. E. Weir and R. A. Schroeder.

Effect of pressure and temperature upon the optical dispersion of benzene, carbon tetrachloride, and water. R. M. Waxler, C. E. Weir, and H. W. Schamp, Jr.

Some changes in double-bond structure during the vulcanization of natural rubber. F. J. Linnig, E. J. Parks, and J. E. Stewart.

Dislocations in polymer crystals. H. D. Keith and E. Passaglia.

Dependence of mechanical relaxation on morphology in isotactic polypropylene. E. Passaglia and G. M. Martin.

Precision density measurement of silicon. I. Henins.

Franck-Condon factors to high vibrational quantum numbers IV: NO band systems. R. W. Nicholls.

Radio Sci. J. Res. NBS/USNC-URSI 68D, No. 10 (Oct. 1964).

Theoretical heights and durations of echoes from large meteors. L. A. Manning.

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Experimental determination of meteoric line densities and attachment rates. L. A. Manning.

Broadband radio-star scintillations, II. Interpretation. D. G. Singleton.

Electron collision frequency in the ionospheric *D* region. R. F. Benson.

A discussion of the theory of ionospheric cross modulation. R. F. Benson.

Theory of a slotted-sphere antenna immersed in a compressible plasma. Part I. Lossless case. J. R. Wait.

Theory of a slotted-sphere antenna immersed in a compressible plasma. Part II. J. R. Wait.

Electromagnetic scattering coefficients for concentric spheres and the problem of interference free enclosures. R. A. Eldred, H. A. Lasitter, and J. Roberts.

Ionospheric sounding using coded pulse signals. D. C. Coll and J. R. Storey.

Measurement of the complex time-frequency channel correlation function. P. A. Bello.

Other NBS Publications

Standard x-ray diffraction powder patterns, H. E. Swanson, M. C. Morris, E. H. Evans, and L. Ulmer, NBS Mono. 25—Sec. 3 (July 31, 1964), 40 cents.

Hydraulic Research in the United States 1964, ed. H. K. Middleton, NBS Misc. Publ. 261 (Aug. 14, 1964), $1.25.

Quarterly radio noise data March, April, May 1963, W. Q. Crichlow, R. T. Disney, and M. A. Jenkins, NBS Tech. Note 18-18 (July 25, 1964), 50 cents.

Factors influencing the design of original-document scanners for input to computers, NBS Tech. Note 245 (Aug. 19, 1964), 35 cents.

Radiochemical analysis: Activation analysis, instrumentation, radiation techniques, and radioisotope techniques, ed. J. R. DeVoe, NBS Tech. Note 248 (Aug. 21, 1964), 50 cents.

Publications in Other Journals

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Preliminary thermodynamic properties of neon, R. D. McCarty and R. B. Stewart (Proc. 1963 Cryogenic Eng. Conf. Univ. Colorado and National Bureau of Standards, Boulder, Colo., Aug. 19-21, 1963), Book, Advances in Cryogenic Engineering 9, Paper D-1, 161-167 (Plenum Press Inc., New York, N.Y., 1963).

Constants of the interpolation formula for platinum resistance thermometers, J. L. Riddle, Proc. Advisory Committee on Thermometry to the Intern. Bureau Weights and Measures, 6th Session, pp. 198-201 (Sept. 26-27, 1962).

N_2^+ oscillators strength from arc spectroscopic measurements using an analog computer, J. B. Shumaker, Jr., Proc. Sixth Intern. Symp. Ionization Phenomena in Gases VII, No. 15, 311-313 (1963).

Ixiolite and other polymorphic types of $FeNbO_4$, R. S. Roth and J. L. Waring, Am. Mineralogist **49,** 242-246 (Mar.-Apr. 1964).

Separation and determination of zirconium in zirconia-yttria mixtures by precipitation with cupferron, E. J. Maienthal and J. K. Taylor, Anal. Chem. **36,** 1286-1287 (June 1964).

Analysis of the frost phenomena on a cryo-surface, R. V. Smith, D. K. Edmonds, E. G. F. Brentari, and R. J. Richards (Proc. 1963 Cryogenic Eng. Conf., Univ. Colorado and National Bureau of Standards, Boulder, Colo., Aug. 19-21, 1963), Book, Advances in Cryogenic Engineering 9, Paper B-7, 88-97 (Plenum Press Inc., New York, N.Y., 1964).

Free subgroups and normal subgroups of the modular group, M. Newman, Illinois J. Math. **8,** No. 2, 262-265 (June 1964).

The operating characteristics of Zener reference diodes and their measurements, W. G. Eicke, Jr., ISA Trans. **3,** No. 2, 93-99 (Apr. 1964).

Four critical fields in superconducting indium lead alloys, S. Gygax, J. L. Olsen and R. H. Kropschot, Phys. Letters **8,** No. 4, 228-230 (1964).

The correlation of thermodynamic properties of cryogenic fluids, R. B. Stewart and K. D. Timmerhaus (Proc. 1963 Cryogenic Eng. Conf., Univ. Colorado and National Bureau of Standards, Boulder, Colo., Aug. 19-21, 1963), Book Advances in Cryogenic Engineering 9, Paper A-3, 20-27 (Plenum Press Inc., New York, N.Y., 1964).

Modern methods of analysis for the design of cryogenic equipment and processes, T. R. Strobridge and D. B. Mann, Symp. The Role Cryogenics is Playing in Expanding Mechanical Engineering, Am. Soc. Refrigerating and Air Conditioning Engineers, New York, N.Y., Feb. 11-14, 1963, pp. 26-37 (1964).

Survey of current NBS work on properties of parahydrogen, R. D. Goodwin, D. E. Diller, W. J. Hall, H. M. Roder, L. A. Weber, and B. A. Younglove (Proc. 1963 Cryogenic Eng. Conf., Univ. Colorado and National Bureau of Standards, Boulder, Colo., Aug. 19-21, 1963), Book, Advances in Cryogenic Engineering 9, Paper, D-9, 234-242 (Plenum Press Inc., New York, N.Y., 1964).

**Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.*

Patents Granted on NBS Inventions

The following U.S. Patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.

3,139,653 July 7, 1964. Apparatus for the growth of preferentially oriented single crystals of metals. Theodore H. Orem.

3,139,658 July 7, 1964. Production of tungsten objects. Abner Brenner, Walter E. Reid, Jr., and Jean H. Connor (Navy).

3,140,990 July 14, 1964. Method of preparation of ozone. James W. Edwards and Joseph S. Hashman (Army).

3,141,238 July 21, 1964. Method of low-temperature bonding for subsequent high-temperature use. George G. Harman, Jr.

3,141,744 July 21, 1964. Wear-resistant nickel-aluminum coatings. Dwight E. Couch, Harold Shapiro, and Abner Brenner (Navy).

3,144,948 Aug. 18, 1964. Collocating machine using a time-position code. Seymour Henig.

3,145,920 Aug. 25, 1964. Floating-point keypunch machine. Anthony A. Berlinsky, Martin J. Brennan, and Charles H. Stockton.

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